Name of the Student:_____
Max. Marks : 27 Marks **Time : 27 Minutes**

Mark Schemes

Q1.

(a) pp nitrogen = 0.25 × 30 = 7.5 kPa **1**

pp hydrogen = 0.75 × 30 = 22.5 or 23 kPa **1**

pp of ammonia = 0.8 × 150 = 120 kPa **1**

(pp hydrogen + nitrogen = 150-120 = 30 kPa)
Alternative method
pp hydrogen = 0.15 × 150 = 22.5 or 23 kPa
pp nitrogen = 0.05 × 150 = 7.5 kPa

(b) $K_p = \dfrac{(ppNH_3)^2}{(ppN_2) \times (ppH_2)^3}$

Penalise [ ] **1**

(c) $K_p = \dfrac{(1.10 \times 10^3)^2}{(1.50 \times 10^2)^3 \times 1.20 \times 10^2}$

No mark for this expression **1**

= 0.0029 to 0.003(0) or 2.9×10^{-3} to $3(.0) \times 10^{-3}$ kPa^{-2}

If expression inverted in 02.2 allow 1 mark for kPa^2
Allow 2.9 to 3(.0) × 10^{-9} Pa^{-2} **1**

(d) decrease/smaller/lower

If increase or no change, 0 marks
If blank, mark on **1**

(Reaction/equilibrium) shifts/moves/goes in the endothermic direction (which is to the left)

Allow reaction is exothermic so equilibrium moves to the left side **1**

to reduce the temperature OR oppose the increase in temperature **1**

[9]

Downloaded from www.merit-minds.com

Q2.

A

[1]

Downloaded from www.merit-minds.com

Q3.

D

[1]

Downloaded from www.merit-minds.com

Q4.

(a) Bonds broken = 2(C=O) + 3(H–H) = 2 × 743 + 3 × H–H

Bonds formed = 3(C–H) +(C–O) + 3(O–H) = 3 × 412 + 360 + 3 × 463

Both required

1

–49 = [2 × 743 + 3 × (H–H)] – [3 × 412 + 360 + 3 × 463]

3(H–H) = –49 – 2 × 743 + [3 × 412 + 360 + 3 × 463] = 1450

Both required

1

H–H = 483 (kJ mol^{-1})

Allow 483.3(3)

1

(b) Mean bond enthalpies are not the same as the actual bond enthalpies in CO_2 (and / or methanol and / or water)

1

(c) The carbon dioxide (produced on burning methanol) is used up in this reaction

1

(d) 4 mol of gas form 2 mol

1

At high pressure the position of equilibrium moves to the right to lower the pressure / oppose the high pressure

1

This increases the yield of methanol

1

(e) Impurities (or sulfur compounds) block the active sites

Allow catalyst poisoned

1

(f) Stage 1: moles of components in the equilibrium mixture

Extended response question

$CO_2(g) + 3H_2(g) \rightleftharpoons CH_3OH(g) + H_2O(g)$

Initial moles	1.0	3.0	0	0
Eqm moles	(1–0.86) = 0.14	(3–3×0.86) = 0.42	0.86	0.86

1

Stage 2: Partial pressure calculations

Total moles of gas = 2.28

Partial pressures = mol fraction × p_{total}

1

p_{CO2} = mol fraction × p_{total} = 0.14 × 500 / 2.28 = 30.7 kPa

Downloaded from www.merit-minds.com

p_{H2} = mol fraction × p_{total} = 0.42 × 500 / 2.28 = 92.1 kPa

M3 is for partial pressures of both reactants

Alternative M3 =

pp_{CO2} = 0.0614 × 500

pp_{H2} = 0.1842 × 500

1

p_{CH3OH} = mol fraction × p_{total} = 0.86 × 500 / 2.28 = 188.6 kPa

p_{H2O} = mol fraction × p_{total} = 0.86 × 500 / 2.28 = 188.6 kPa

M4 is for partial pressures of both products

Alternative M4 =

pp_{CH3OH} = 0.3772 × 500

pp_{H2O} = 0.3772 × 500

1

Stage 3: Equilibrium constant calculation

$K_p = p_{CH3OH} \times p_{H2O} / p_{CO2} \times (p_{H2})^3$

1

Hence K_p = 188.6 × 188.6 / 30.7 × $(92.1)^3$ = 1.483 × 10^{-3} = 1.5 × 10^{-3}

Answer must be to 2 significant figures

1

Units = $\underline{kPa}^{-2}$

1

[16]

Downloaded from www.merit-minds.com